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Design thinking for the development of formal operations: A team-based middle school design curriculum

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DESIGN THINKING FOR THE DEVELOPMENT OF FORMAL OPERATIONS: A TEAM-BASED MIDDLE SCHOOL DESIGN CURRICULUM

A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Art Education at Virginia Commonwealth University.

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In this thesis, I propose a team-based design curriculum that aligns with the cognitive development of middle school age students. The ability to think abstractly develops at a specific time in development, according to widely accepted cognitive theory. The middle school years are the launching pad of abstract thinking. At this age, students are also primed for learning through social activity. The design process often includes abstract problem solving challenges, and working within a team structure. These ideas build a foundation for a research question—could a team-based design curriculum in middle school strengthen students' natural cognitive development by providing opportunities for adaptations through experiential learning? In this thesis, I propose a team-based design curriculum for middle school students, which follows a trajectory of concrete to abstract challenges, complementing the natural cognitive transition of this age.

CHAPTER 1

"The principal goal of education in the schools should be creating men and women who are capable of doing new things, not simply repeating what other generations have done."

– Jean Piaget, *The Origins of Intelligence in Children*, 1952

Introduction: A Memory

Designing has been part of my life for many years. In the early years of the public internet and personal computers in schools, I was an elementary school student using KidPix to create digital art, adding typography and customizing colors in my designs. Software like HyperStudio hypnotized me with the possibilities of user interfaces and interactive design. In middle school, I learned basic HTML code and used it to design websites for myself and my friends. These early experiences are the foundation of my current interest in design. After pursuing graphic design in college, I worked in a professional design firm for five years, serving as Senior Designer and participating on a regular basis in a group process to develop designs. Working within a team was new to me, since in school we always worked on our own concepts, designs and revisions. In the professional world, I noticed that there were no designs created in solitude. Series of meetings with copywriters, content strategists, web programmers and clients showed me what working as a designer really meant—sharing ideas, pushing each other for better work, supporting one another, and creating long-lasting team and social relationships. While guiding new design interns in the office, I realized that I enjoyed the educational aspect of the position more than the hustle and bustle of office life. Eventually, my passion for design led me to begin teaching it.

In my graduate research in art education, I focused on the topic of design. I was pleased to find several current arts educators writing about design in the K–12 environment, however, I was surprised that many of the suggestions for design curricula relied on the use of expensive digital technologies, like computer labs with Adobe Creative Suite or classroom sets of iPads. I became interested in creating a design curriculum that does not rely on the use of expensive technology and is accessible for many classrooms.

While teaching in a local art museum’s youth summer program, I explored this idea to teach design concepts and design thinking without the use of expensive digital technology. I created a new week-long course based on this goal that was aimed at ten to twelve year old students. In creating this class, I planned to teach using a team-based approach for several reasons—many designers in the professional design field work in this way, designs are shaped through group brainstorming and consensus, and students of this age group seem to engage more readily with activities when a social aspect is present.

Our class project was to design a community together. The topic was left very open to allow students to direct the outcome. Together, we determined buildings, systems, landscape features, community values and more. In the initial stages of planning, we cycled through opportunities for individual concepting, sharing with a partner, and whole-group class brainstorming. One day, the students’ various approaches to an individual sketching activity caught my attention. During individual sketching time, when students were tasked with plotting out their ideal version of our ‘community,’ I noticed distinct differences among some of the students' sketches. While we had never called it a 'city,' 'neighborhood,' or anything else specific, the students' work fell into two main categories. Several students had drawn tidy little boxes, all fitting perfectly together like a game of Tetris, with neat labels in each box. When I first noticed a student filling her page with tight city blocks, I was intrigued by her choice of a strict city grid. As I worked my way through the class, I saw another young student with an almost identical Tetris approach. Other students were looser in their interpretation and drew various types of landscapes with buildings and structures arranged in creative ways.

I wondered to myself, "why, when presented with unlimited possibilities, would some students choose to work within the confines of the grid?" There was one discernible difference between the approaches; the students who chose the straightforward approach were the younger students in my class, while the older students imagined grand possibilities "outside the box."

Why would the age difference of one year make such a drastic shift in creative thinking? This question led me to research cognitive development as it relates to creative thinking, specifically the constructivist research of Jean Piaget. In conjunction with this, I was interested in learning more about the intersection of group process and design process. I had participated in this intersection during my time as a designer in a professional studio, but had lacked this experience in my design education. How might the group process influence the development of design thinking in students? This question led me to the social-constructivist works of Lev Vygotsky, specifically his Zone of Proximal Development. In this thesis, I will explore the connections among these topics, and put forth a design curriculum based on my research.

Statement of the Problem

Our students are tested, stressed and burdened with standards and expectations that were designed for an educational assembly line—a machine with no regard for the unique intellect of the child it is producing. According to philosopher, epistemologist, and psychologist Jean Piaget, children's brains have unique abilities and limitations at each stage of their cognitive development. As the child grows, the brain grows, and it is capable of new things. While children age two to seven mostly comprehend the immediate space around them and the world of their imagination, a child between seven and eleven begins to see the world as a bigger, more concrete place (Singer & Revenson, 1996). A typical child is not going to leap ahead to the next cognitive stage until she is biologically ready; however, education can capitalize on the natural stages of cognitive development in children. By participating in curricula that maximize the use of skills unique to a particular stage of development, students are set up with a strong foundation for success in the following stage. In design, one must think abstractly as well as often work with others in teams. Without these factors in design education, the design experience is not reflective of real-world design challenges. The problem I've identified is related to three strands that braid together: Piaget's stages of cognitive development, current design education in the U.S., and Vygotsky's theory that knowledge is socially constructed.

Piaget's Stages of Cognitive Development

The foundation of my research is Piaget's theory of cognitive development. He identifies the stages of cognitive development from birth to age two as *sensory-motor*, age two to seven as *pre-operational*, seven to eleven as *concrete operational*, and eleven to sixteen as *formal operational* (Singer & Revenson, 1996). Children transition through these stages by "continuous organization and reorganization of experience" (Singer & Revenson, 1996, p. 13). Each experience is an opportunity for the child to categorize new information into her existing knowledge, or create a new space of understanding for it. Through cycles of creating adaptations, the student drives her own cognitive development (Ginsburg & Opper, 1979). Underlying this cycle of adaptations are four factors that drive development. Piaget identifies *maturation*, *experience*, *social transmission,* and *equilibrium* as the factors that come together for an adaptation to occur. As educators we must consider these factors in the cognitive development of our students.

While students will naturally progress through the stages of cognitive development in an ordered way, Kuhn (1979) notes that "the stage of formal operations, unlike the earlier stages in Piaget's sequence, is never attained by some significant number of individuals" (p. 35). Even though a student might be biologically ready for the transition to formal operations, they might not be experiencing cognitive adaptations that move them towards higher cognitive functioning. Kuhn also notes that formal operations continue to form throughout life. Some individuals face cognitive challenges that move their progression towards stronger formal operational thought, and others are not pushed to use abstract thinking skills to adapt to challenges. This is the problem with formal operations—the cognitive development of the child is dependent on the experiences of adaptation.

Although every stage is worth researching in regards to designing curricula, in this paper I focus on the transition from concrete to formal operations, around ages ten to twelve. A child of this age is transitioning to more flexible and abstract thought (Singer & Revenson, 1996). "The individual can now conceive all the possible ways a problem might be solved, and can look at a problem from several points of view" (Singer & Revenson, 1996, p. 26). This is the essence of design thinking, and ties directly to the current approach to design education, and Vygotsky's theories of knowledge being socially constructed.

Design Education

Design education today has a variety of goals: developing 21st century skills, building problem-solving skills, career skills and economic, social and cultural aims (O'Donoghue & Berard, 2014; Vande Zande, 2007, 2010, 2014). The problem with design education is that while we are connecting to the importance of teaching students these skills and values, there is opportunity to apply targeted design curricula with a foundation in cognitive theory. If we look to Piaget's stages of cognitive development, there are phases where design education best complements the natural skills of the child. While a pre-operational six year old might be a sponge for learning the names of design elements, the abstract nature of sophisticated design principles would be beyond her interests and comprehension. When the concrete operational seven year old begins to see the world as larger than herself, principles like harmony and hierarchy will fall into place. My research focus is the child transitioning away from concrete thought and laying the foundation for abstract thought—formal operations. Singer and Revenson (1996) write that the formal operational child "can think about such abstract concepts as space and time…he develops an inner value system and sense of moral judgement. He now has the necessary 'mental tools' for living his life" (p. 26). How might we better prepare students in abstract thinking for the challenges they will face in the future?

Piaget's theory of adapting through experiential learning mirrors the process of design. Designing is the way we adapt to our world. Humans have used problem-solving and creativity together for hundreds of thousands of years to create innovative tools and solutions to the problems we face (Adler et al., 2014). Vande Zande (2007) writes “designing is an innate facility apparent in humankind” (p. 47). She calls to art educators to take the lead in design education and provide students with opportunities to create, select and arrange the objects in their environment. Piaget (1952) emphasizes the importance of children’s engagement with their environment as central to adaptation, and therefore the process of cognitive development.

Many educational programs proposed today include invention and problem-solving tasks, but Vande Zande (2007) says “most of what is being addressed about functional design in other subject disciplines and organizations is closely related to engineering and culture. They are not teaching aesthetics and meaning-making aspects of design that reach deeply into the human spirit. This is the domain of art education” (p. 46–47). A design curriculum that is based on increasingly abstract problem-solving challenges could align with the natural transition from concrete to formal operations, maximizing on the unique skills of the age.

Team-based learning

In his theories, Piaget specified *social transmission* as one of the four factors contributing to the development of cognition. Ginsburg and Opper (1979) emphasize that this term is used in a broad sense, and refers to any knowledge passed between people whether at home, with friends, or at school. This passing of knowledge enables children to learn through the experiences of others. Another well-known theorist, Lev Vygotsky, is the champion of this transmission of knowledge, which he described as social-constructivism. Vygotsky made social interaction and transmission the basis of his theory of human development and ideation (Ginsburg & Opper, 1979). Vygotsky’s theories provide support for team-based learning strategies, and when paired with Piaget's natural stages of development, create strong evidence that students could benefit from working within this structure.

The problem with team-based learning is that it is more appropriate at certain stages of a child's cognitive development. In the same way that young children might benefit from incorporating play into a curriculum, older children have other needs to match their stage of development. Piaget identifies that "older children develop a morality of social concern and cooperation" (Ginsburg & Opper, 1979, p. 6). Before the stage of formal operations, children have limited cognitive flexibility to see the viewpoints of others. When transitioning to formal operations around the age of ten to twelve, the seeds of social concern and cooperation are planted.

As Gulley (1968) notes, "individuals bring unique talents, abilities and interests; various combinations lead to varied group functioning" (p. 250). By working in a team, members are pushed to recognize productive changes in their own behavior (Harrington-Mackin, 1994). By fulfilling group goals, the member also feeds her own needs, since she has aligned herself with the goals of the group. Harrington-Mackin (1994) cites that "the results of extensive research indicate that collective decision making is a more productive process that individual decision making" (p. 95). Students in the transition from concrete to formal operations are primed for social activity, which can be channeled to facilitate collective team-based decision making strategies through the design process.

The group process and the design process naturally overlap in many fascinating and mutually beneficial ways. This complex relationship, in addition to the intricacies of Piaget's and

Vygotsky’s theories regarding development and knowledge, will be explored further in the review of literature.

Conclusion

The curriculum I propose is a team-based design curriculum for a specific age group. Piaget emphasizes the qualitative nature of assessing cognitive development. While there are markers and milestones, no standardized test can truly gauge a child’s deep and unique intellect (Ginsburg & Opper, 1979). There is a need for this study to develop a more targeted approach to design curriculum based on Piaget's stages of cognitive development, and aligned with Vygotsky’s theories of social acquisition of knowledge. This problem impacts students transitioning from concrete to formal operations. This study contributes to the body of knowledge needed to address this problem by answering the question: could a Vygotskian team-based design curriculum in middle school strengthen students’ natural cognitive development by providing opportunities for Piagetian adaptations through experiential learning?

CHAPTER 2

Review of the Literature

In this review of literature, I will weave together three threads that become the foundation of my research: 1) Piagetian cognitive development theory, 2) design thinking, and 3) team thinking.

Theory of Cognitive Development

The first thread central to the proposal of curriculum that follows this chapter is a widely accepted constructivist theory of cognitive development.

Piaget's stages of cognitive development. The prominent Swiss psychologist, Jean Piaget, designed his theory of cognitive development based on four predictable stages of growth. He identified these stages as *sensorimotor*, *preoperational*, *concrete operational*, and *formal operational*. Children develop through these stages at their own pace, but they will follow a predictable order. In the *sensorimotor* stage, which Piaget's theory says is between birth and two years of age, the child learns by experiencing the world directly through her senses. She develops skills of recognition and practices the mental act of thinking, making connections between observations of her environment. During the following *preoperational* stage, around ages two to seven, children see their world from an egocentric perspective, and have difficulty seeing it from other perspectives (Dimitriadis & Kamberelis, 2006). The child of this stage is learning by assigning language to symbols of the world around her (Dimitriadis & Kamberelis, 2006). Piaget's third stage of cognitive development is *concrete operational*. The concrete operational child, around ages seven to eleven, begins to understand concepts of space and classification, but thinks of the world in concrete, literal terms. She has difficulty thinking abstractly and hypothesizing about outcomes of situations. The final stage that Piaget identified is *formal operational*. With this development comes abstract thinking and hypothesizing. Sometime around ages ten to twelve, children begin their transition to formal operations. This transition from concrete to formal operations is the primary thread of my research interest.

Concrete to formal operations. When young people are transitioning from concrete to formal operations, they gain many skills of cognition unique to the higher thought processes of humans. Although we know *Homo erectus* was able to control fire thousands of years ago, it is said that *Homo sapien* was the first species to create fire through the use of tools, performing mental problem-solving tasks to overcome a challenge. This is the uniquely human cognitive ability for formal operations. Humans have always been innovators, using problem-solving and creativity to better their daily lives and societies (Adler et al., 2014). The ability to think in this way is rooted in formal operations. Rather than thinking only about the present tangible evidence, the individual of formal operations is able to conceptualize and envision abstractly from multiple perspectives (Singer & Revenson, 1996). Developing this kind of thinking is key to adapting to the real-world challenges of the future.

Transitioning between stages. Piaget identified four factors that contribute to the process of transitioning between stages of cognitive development: biological maturation, experience, social transmission, and equilibration. In reference to biological maturation, Piaget says that children will only develop cognitively when they are biologically ready (Ginsburg & Opper, 1979). The brain of a young person is not ready for higher stages of cognitive development until it physically develops to a certain point. Piaget's second factor for transitioning through the stages of cognitive development is experience. Humans learn through hands-on experience with the world around them. Singer and Revenson (1996) reiterate Piaget's belief that "...children learn about the world through their active engagement" (p. 11). Experiencing and interacting with the world provides opportunities for adaptations. The third factor for cognitive development that Piaget identifies is social transmission. Although he says that younger children are egocentric and only see the world from their own perspective, he also acknowledges that the social experience of interaction is key to cognitive development. Through working with peers and teachers, we gain language and information that we then assimilate and accommodate into our existing knowledge, resulting in adapting to the world. Piaget's final factor that he says contributes to cognitive development is the idea of equilibration. Equilibration is the process of trying to assimilate new knowledge into existing knowledge, and rearranging existing knowledge to fit new knowledge.

Piaget says the transition between stages of cognitive development happens through repeated cycles of making adaptations to the world (Dimitriadis & Kamberelis, 2006; Ginsburg & Opper, 1979; Singer & Revenson, 1996). When we are presented with new or unexpected knowledge, Piaget says we try to organize it into our existing knowledge, or *assimilate* it, and try to rearrange our existing knowledge to fit the new knowledge, or *accommodate* it. Using the processes of assimilation and accommodation together, humans experience cognitive *adaptations*.

Figure 1. Piaget describes the process of creating cognitive adaptations for new knowledge.

Adapting to the world through assimilation and accommodation of knowledge means thinking abstractly to develop innovative solutions to the challenges we face. This is the backbone of cognitive development.

Since every child's cognitive development happens at their own biologically rooted pace, the transition can't be forced to occur faster, but education strengthens and facilitates the process by providing relevant experience. Formal operations can become stronger with practice (Ginsburg and Opper, 1979). With a repeated cycle of equilibration, the brain becomes more adept at making adaptations, strengthening formal operations.

Although ten to twelve is the primary age range for the beginning of the transition from concrete to formal operations, the development of formal operations is ongoing throughout adolescence and adulthood. The age of transitioning to formal operations is the prime time for strengthening muscles of cognitive development. In the same way that younger children are adept at language acquisition, the child of ten to twelve is primed for increasingly abstract thinking.

There is opportunity at this stage of cognitive development to present our students with abstract challenges of new knowledge resulting in equilibration and adaptation.

Design Thinking

The second thread of my research is design thinking in art education.

Identifying *design*. The term *design* is used in many ways. As a noun, a design is typically the outcome of a creative process that combines form and function. As a verb, to design means engaging in the *design process* while implementing *design thinking*. The design process includes cycles of creating and revising adaptations to challenges. Art and design educator, Robin Vande Zande (2007, 2014), defined the design process as a series of steps to create a design solution. She includes identifying the problem, investigating and researching, generating ideas, prototyping, presenting, and revising as common stages in the process. In much of the recent literature, the terms *design problems* and *design solutions* are used in reference to the design process. For semantic reasons, I will instead use the terms *design challenges* and *design adaptations* for these concepts because the words problem and solution imply that there is one correct solution to any singular design challenge. Often in design, the problem is less of a problem and more of a need, and there are many ways to successfully fulfill these needs. The design process is very open-ended, and can lead to infinite adaptations to challenges.

Design thinking is the cognitive activity that happens during the design process (Watson, 2015). Optimism is the driving force behind design thinking; design thinkers have hope that the current state of something has the potential to be better (Bell, 2008; Brown, 2008). Designers feel empathy to a certain problem, and seek a solution for a utopian future through emergent solutions (Boelen, 2012; Brown, 2009; Collins, 2013). "Design considers the exhilaration of utopia, but because of its everyday nature, also grounds itself in the actual" (Boelen, 2012, p. 12). Vande Zande (2007) says "on one level, design is a profession with particular skill sets and theories that are taught, but on another, designing is an innate facility apparent in humankind" (p. 47). Through design thinking, humans adapt our everyday lives to be easier and more pleasant.

These terms are not limited to any particular discipline in design—interior, graphic, product, etc.—but instead refer to the universal human need to design the world around us. By engaging in a design process using design thinking, we design adaptations for ourselves.

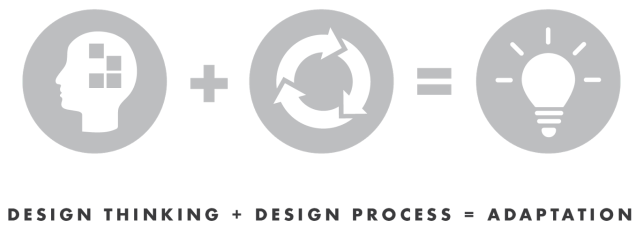

Figure 2. The act of designing is using design thinking in the design process to create adaptations.

Design adaptations and cognitive development. The process of using design thinking to create adaptations mirrors the process Piaget describes in creating adaptations for cognitive development. These uses of *adaptations* differ in that the design process is concerned with creating a cohesive output, while Piaget is talking about the development of the brain itself, but both have the same goal of adapting to cognitive challenges. At its essence, design thinking is assimilating information, accommodating it, and creating adaptations to overcome challenges.

History of design education. Design and design thinking have been popular themes in the recent literature of art education. The 2015 National Art Education Association (NAEA) annual convention in New Orleans was themed around "The Art of Design" and featured many panels describing the incorporation of design education in the art classroom. Leading up to the 2015 convention, the NAEA publication, *Art Education*, featured a special issue titled *The Art of Design: Form, Function, Design and the Future*. Several researchers in recent years have studied ways of teaching design thinking through problem-solving based curricula (Carroll et al., 2010; Watson 2015). Understanding the current state of design education requires some background knowledge of design education in the 20th century, especially from the well-known Bauhaus school in Germany.

The Bauhaus was created in 1919 as a merger of Weimar Arts and Crafts School and Weimar Art Academy (Meggs & Purvis, 2006). Under the direction of architect Walter Gropius, the Bauhaus sought to teach a unified arts and crafts curriculum that embraced modern technologies (Hochmann, 1997). The Bauhaus school arose from utopian ideals in a time when war-torn Europe left citizens living in filth and starvation (Hochmann, 1997). In reaction to modern industrial advancements, Gropius's Bauhaus manifesto asks:

> How can we escape this directionless whirlpool and give the younger generation the necessary elasticity, independent judgment, and moral resistance to enable them to withstand the avalanche of pseudoproducts that threaten to choke us? (as translated in Neumann, 1993, p. 13)

This utopian design thinking was the foundation of the influential Bauhaus school, in an effort to teach students flexibility in creative thinking and technical hand-working skills while embracing emerging technologies with the goal of creating a more enjoyable world (Hochmann, 1997). Although the school was forced to close in 1933 by the Nazis, the legacy of the Bauhaus design education model is influential in many contemporary design programs (Wick, 2000).

The Bauhaus is arguably the most prominent historical model of design education, however it was a post-secondary institution. My interest is in the inclusion of these design ideals in K–12 education. Vande Zande (2002) describes the history of design instruction in American

Schools. She traces design education in the K–12 environment to the inclusion of technical drawing in arts education in the 1860s, as a means to prepare future industrial workers. Through the next hundred years, design education saw little change. The subject was mostly either taught as a means for preparing students with professional skills or handicraft skills.

Goals of contemporary K–12 design education. Design education of today has many goals; improving problem-solving skills, encouraging collaboration, promoting sustainable practices, and economic and cultural aims, among others (Carroll et al., 2010, Vande Zande 2007, 2010, 2011, 2014; Watson, 2015). Vande Zande (2007) identifies four main categories of design that are currently addressed in K–12 art education: objects, communications, environments, and experiences. Also currently popular in design education are concepts of sustainability (Hasio & Crane 2014; Vande Zande 2011). Most importantly, design thinking emerges as a prominent theme in educational literature (Carroll et al., 2010; Vande Zande, 2007, 2014; Watson, 2015).

Vande Zande (2007) discusses the value of design and problem-solving to humans as a species. Design is concerned with adapting to challenges using technical skills, concerns of aesthetics, social issues and cultural and personal meanings. Lessons in design should be aimed at helping students recognize and appreciate well-designed objects that combine form and function, understand sustainability practices, learn about professional designers, use invention and imagination to overcome design challenges, understand interconnectedness of ideas and events that are central to design, incorporate compositional elements in viewing and creating design objects, improve technical skills, and build awareness of how and why design decisions are made that affect daily life.

In 2014, Vande Zande writes that we can train students using the design process as a framework for using design thinking to identify and adapt to complex, multi-disciplinary, open-ended challenges and real-life experiences. Two recent studies emerged as successful examples of implementing design curricula to improve design thinking skills in students.

Design thinking for life. In his 2015 article regarding an observational case study research project, Andrew Watson describes the results of implementing a design thinking curriculum with his high school students. Through student interviews and class discussions, Watson sketches a picture of design thinking's impact on students. He finds that open-ended discussion is very important; student perspectives drive the design process. In his class, students work in collaborative teams. They reflect on their understanding that professionals often work in teams, and also the fact that they wouldn't be able to solve many of the design challenges they face alone.

Watson's thoughtful students make an interesting point about metacognition and design. While working through the design process using design thinking, students he interviewed report that it made them formalize the thinking process. By using metacognitive thinking and having a predictable path to guide them, the design process helped get them out of being stuck. Watson reiterates this, writing that "formalizing the process helped them to solve larger and more complex problems" (p. 16). Watson's study demonstrates the value to students of implementing the design process in a team-based structure.

Design thinking and imagination. A 2010 ethnographic case study titled "*Destination, Imagination and the Fires Within: Design Thinking in a Middle School Classroom*"

(Carroll et al., 2010) describes a curriculum designed for a middle school geography class. In this study, researchers sought to find the role of design thinking in K–12 classrooms.

This study identifies design thinking as exploring all aspects of challenges through multiple sources and iterations. They found that design thinking skills provided many benefits to students. Design thinking develops students' creative confidence, builds empathy, encourages ideation, fosters problem-solving skills, and strengthens imagination (i.e. cognition, stretching the possible world). In addition, students saw the power of risk taking, strength in collaborative effort, and learned ways to develop as a successful collaborator. Carroll et al. (2010) report that design thinking "challeng[es] students to find answers to complex and difficult problems that have multiple viable solutions and by fostering students' ability to act as change agents" (p. 38). They go on to emphasize that "collaborative experiences are the foundation of design thinking"(p. 39). This study demonstrates the benefits of implementing the tools of design thinking in the classroom.

Other themes in design education. O'Donoghue and Berard (2014) address environmental and social issues, as well as being attentive to the context of the design; for example, what students can relate to in their daily lives rather than production of material goods. They say it is important to teach design as a participatory activity, involving the designer and the users. They suggest that blurring distinctions between design disciplines allows for an open-ended, 21st century approach to problem-solving.

Some resources already exist for educators seeking to incorporate design challenges in their curricula. The website *learnXdesign.org* is a resource for low-cost design projects, suitable for all levels of K–12 students. While it is not an arts based approach to design thinking, it is aimed at building problem solving and team collaboration skills. Recent case studies mention curricula that rely on expensive digital technology like Apple computers with iMovie and classroom sets of iPads (Carroll et al. 2010), but not all educators have these resources available to teach design.

Many authors discussing design thinking cite 21st century skills as the benefits to our students (Carroll et al., 2010; Vande Zande, 2007, 2010, 2011, 2014; Watson, 2015), but we can't overlook the intrinsic value of arts education. It is popular to think of design thinking in terms of turning our students into the skilled workers of the future. In her 2010 article "Teaching design education for cultural, pedagogical, and economic aims," Vande Zande supports this, referring to Nyquist (1929) calling for cultural, pedagogical and economic aims for art education. Several educators promote using design education as a means to train students as professionals (Carroll et al., 2010; Vande Zande, 2010, 2014; Watson, 2015). In 2014, however, Vande Zande emphasizes advancing cognitive development as a primary pedagogical aim of incorporating design education.

Design in art education. Vande Zande (2007) says "this is a propitious time for art educators to take the lead in design education, directing students through a study of human nature in covering the creation, selection, and arrangement of the objects in their environment" (p. 50). She says that recently, functional design is mostly addressed through the lens of engineering and culture, rather than the meaning-making aspects of an arts-based approach to design education. "The formal study of design principles and processes could expand upon this innate drive [to design], guide students to be able to create and appreciate the elegance of good functional design, and help them to understand how behavior is influenced through objects and images that surround us daily" (p. 48). The unique studio structure of arts education is suited to design education. Hetland (2013) says studio practice is where "critical judgement and metacognition are nurtured" and students are "thinking visually, analytically, critically [and] creatively" (p. 13). The environment of the visual arts classroom is uniquely suited to promote creative problem-solving.

The literature shows that design and design thinking are important aspects of a 21st century arts education. How might we implement design curricula in targeted, theory-based ways for the development of cognition in our students?

Team Thinking

The third thread woven into my research is the social development of knowledge.

Social construction of knowledge. Prominent developmental psychologist Lev Vygotsky contributed theories that add to Piaget's work. While Piaget lays the foundation for the stages of cognitive development, Vygotsky shows how our social context influences our cognition. He says that cognitive development happens within social groups, where he finds the Zone of Proximal Development (ZPD). Humans are a social species, and we learn through our social context and language. He says that interactions are translated into higher-level mental functions such as memory and abstract thinking, emphasizing that nobody learns alone (Dimitriadis & Kamberelis, 2006). "According to Vygotsky, the most effective forms of teaching-learning processes occur within the ZPD" (Dimitriadis & Kamberelis, 2006, p. 197). Vygotsky's theories of socioconstructive development support the third thread of my research.

Vygotsky *contra* Piaget. While both developmental psychologists are concerned with the complex ways that humans develop knowledge, there are some striking differences in theory.

The primary conflict between the theories is that while Piaget claims that development leads to learning, Vygotsky says that learning leads to development (Dimitriadis & Kamberelis, 2006). In Piaget's theory, he says that the biological stages of cognitive development naturally lead to learning—the student learns only as much as she is developmentally prepared for. In contrast, Vygotsky's theory says that regardless of age, we learn through social processes, and this gaining of knowledge and skills fuels our development.

Another contradiction between Piaget and Vygotsky is the purpose of language in cognitive development. Piaget writes extensively on how language relates to knowledge. He says that in the early stages of cognitive development, language and thought are not related in important ways, and that cognition would develop normally even without the use of language. Dimitriadis and Kamberelis (2006) explain that "for Piaget, thought development precedes language development. Language is simply a reflection of the thought" (p. 174). Instead, Vygotsky claims that language is central to the development of cognition. We gain our knowledge from the people around us—parents, siblings, peers, teachers, and neighbors.

Although Piaget and Vygotsky have some opposing viewpoints, they are mostly in regards to the earlier stages of cognitive development than the transition to formal operations, which will be the focus of the following chapters. Both Piaget and Vygotsky agree that language and social interaction are important aspects of cognitive development during the age of transitioning to formal operations. Piaget's and Vygotsky's theories can exist simultaneously and be intertwined together, with cognitive development happening both within the individual, and in the social group.

Team process and the creative process. The team process and creative process overlap in many ways. Harrington-Mackin (1994) describes a team decision making process that closely aligns with the steps of the design process presented by Vande Zande (2007). In the May 2015 issue of *Art Education*, Watson shows that working in teams influences creativity. He notes that the professional design process is almost always a team process—in addition to the designer there might be a client, copywriter, project manager, printer, and many more players. "The results of extensive research indicate that collective decision making is a more productive process that individual decision making" (Harrington-Mackin, 1994, p. 95). The creative design process is inherently collaborative, and collaboration can positively influence creative outcomes.

Conclusion

There is an opportunity for education to complement cognitive development, specifically the natural transition from concrete to formal operations around ages ten to twelve. Design thinking, when combined with the design process, parallels Piaget's process of creating adaptations that facilitate cognitive development. Designing in teams strengthens design adaptations, strengthening formal operations. Curricula could align with these interwoven threads, combining team-based design thinking challenges with the goal of Piagetian adaptations for cognitive development.

CHAPTER 3

Proposal of the Curriculum

In the following chapters, I will propose a team-based design curriculum for ages ten to twelve, that is rooted in Piagetian cognitive development theory and Vygotskian social constructivism. The curriculum includes three overlapping parameters to guide students' trajectory from concrete to formal operations: Piaget's stages of cognitive development, goals of 21st century design education, and Vygotsky's social construction of knowledge.

Piaget's four factors for adaptations will be addressed throughout the curriculum—maturation, experience, social transmission, and equilibrium. These factors must be present for cognitive development to progress.

Vygotsky emphasizes three factors for the socially constructed development—cultural context of knowledge, the individual as part of the social group, and the use of human language (Wertsch, 1988). These factors must also be present for cognitive development to progress.

Vande Zande addresses four main categories of design in art education—objects, communications, environments, experiences. Design curricula should address these varied and open-ended topics, rather than focusing on narrow disciplines and divisions in the professional design world.

This curriculum is unique compared to existing models in that it addresses a targeted audience at a particular point in their cognitive development. It also combines this transition with social construction of knowledge, for which this age group is primed. The curriculum that follows is firmly rooted in art education rather than as a way to integrate design thinking into other subject areas. While working in teams, we will explore increasingly abstract issues of the world for the development of students' cognition.

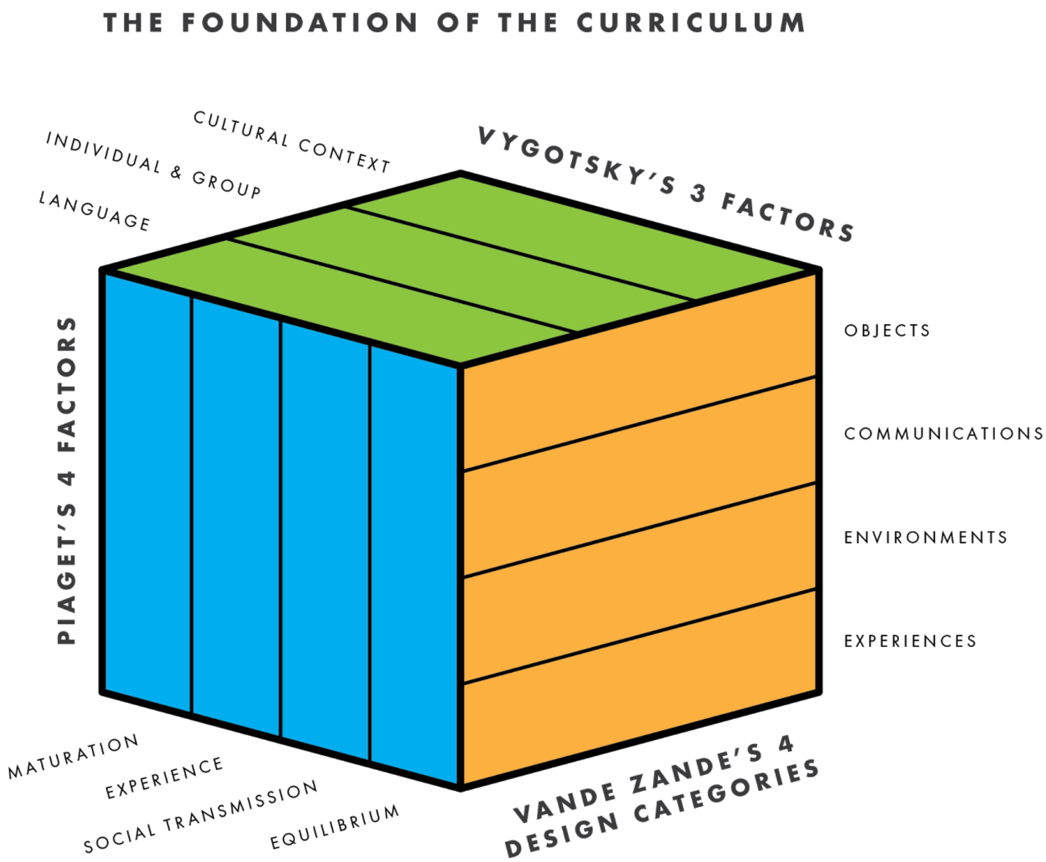

Figure 3. A design curriculum based on weaving together the works of three theorists.

CHAPTER 4

Methodology

Introduction

The methodology implemented in this research is based on the complementary braiding of the three theoretical strands: Piaget, Vygotsky, and 21st century design education. These three strands are inseparable and rely on each other to build a theoretical foundation for a design curriculum. Without one strand, the curriculum is weakened and the opportunity for strengthening formal operations is diminished. The curriculum proposed here incorporates several self-imposed parameters that serve to guide the units in strengthening students' transition from concrete to formal operations. A curriculum should present content of interest to the students, be developmentally appropriate, and employ effective learning strategies. The parameters outlined in this chapter aim to fulfill these goals and braid together the three strands of this design curriculum: Piaget's theory regarding the transition from concrete to formal operations, the content of design education, and Vygotsky's theory of social construction of knowledge. In this chapter, I will examine the relationships among these factors and determine guidelines for implementing this design curriculum.

Target demographic

Age range. The target age range for this curriculum is ten to twelve years old. Piaget's research and theory defines this age as the primary range for the initial formation of formal operations. This age range occurs during the average 5th to 7th grade in American schools. However, teachers should consider their own students since the transition is gradual and based on many variables noted in the review of literature. Some ten year olds might not be developmentally ready for a curriculum based on this transition, and attempting it could cause frustration and feelings of anger for them. Likewise, older students who are already on their way to formal operations might not find these abstract design problems challenging enough, and are instead ready to begin exploring larger issues of humanity (I suggest further research into methods of advancing formal operations with adolescents 13–17). Overall, ten to twelve year olds are in the prime age range for the transition from concrete to formal operations.

Accessibility & cost. This curriculum is designed to be low-cost and reliant on available materials, rather than depending on expensive digital technologies. My hope is for the curriculum to appeal to many teachers as an interesting possibility for their students. The curriculum is meant for American middle schools, regardless of budget or available resources. It emphasizes abstract thinking for the cognitive development of all our students, regardless of economic means. A teacher might have access to digital resources and decide for themselves to incorporate software skills into teams' designs or presentations. Technology can be a powerful tool for creation in design, but it may not be available to all populations.

Timeline of the Curriculum

This curriculum comprises eight units, each estimated to be four weeks long, to create a 32-week curriculum. This length was chosen to create a curriculum possible over the course of a full school year, excluding holidays and testing periods. This extended timeline allows for repeated cycles of Piagetian adaptations. Without repeated cycles, students only have isolated experiences that do not relate to the larger and more abstract picture of the world. It is not recommended to attempt to speed up the process of transitioning to formal operations by rushing through a full curriculum like this. The transition from concrete to formal operations should happen naturally, and uniquely, for students.

This extended timeline also allows for a gradual transition through increasingly abstract design challenges. The beginning phase features concrete challenges, while the final units are more abstract, requiring formal operational skills. Several cycles of adaptations between these two points gradually help students to build their design thinking and abstract thinking skills. This sequencing is crucial to complementing the natural, gradual transition from concrete to formal operations. Although the sequence from concrete to abstract is of utmost importance, the units presented here are not the only design challenges that could help in the Piaget transition. The curriculum is not prescribed, but instead builds its own path toward increasingly abstract challenges. Perhaps students express interest in other design opportunities—the teacher can then respond to their input and allow them the room to grow.

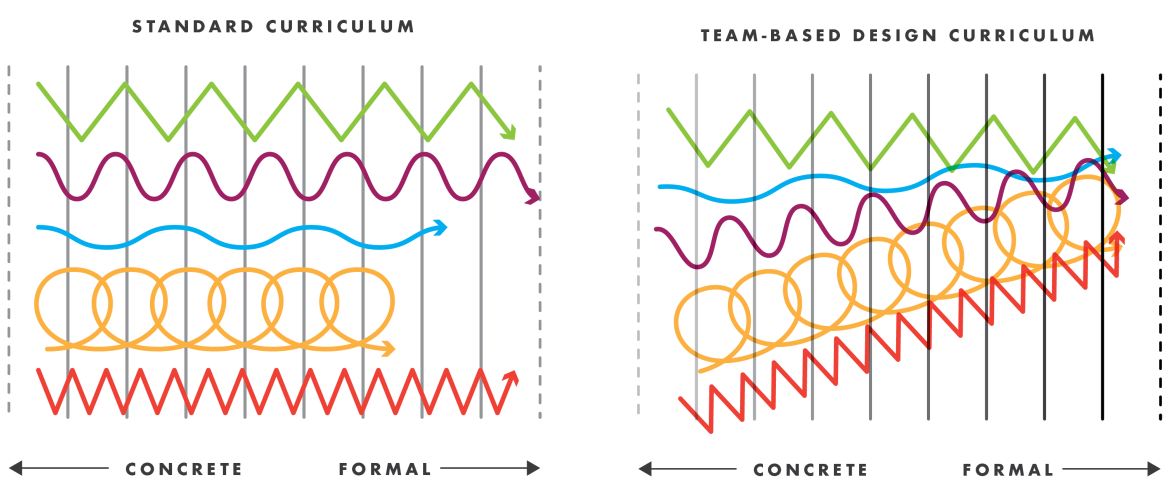

Figure 4. In a standard curriculum, students move through the stages of development at their own pace and with minimal interactions, while in a collaborative curriculum based on increasingly abstract challenges, students help each other adapt and strengthen formal operations in a social constructivist setting.

A curriculum like this could potentially be stronger with block scheduling to accommodate for longer periods of design thinking and hands-on making, although a school with 45-minute periods should be able to implement the curriculum. For schools with shorter class periods, I would recommend pacing out the proposed unit segments over several class sessions.

Format of the Design Units

Design challenges. The design challenges suggested in the curriculum relate to the context of students' lives. Piaget (1952) says children can best relate to what is immediately around them at the concrete operational stage. This reasoning becomes more abstract over the transition from concrete to formal operations, and pushes beyond the student's immediate context. In the later, more abstract units in the curriculum, students are guided to think about individuals as part of a class, school, and community. These abstract relationships are too far removed from reality of the concrete operational child.

Vygotsky also emphasized the importance of the cultural context of knowledge (Wertsch, 1988). Knowledge is linked to the place and time of people. Students in this curriculum would focus on design challenges that relate to their own personal context, not that of someone in a different place or time (i.e. designing a lunar lander or hospital in Africa). This allows an entry point for students, and an appropriate context for them to work within. Students might one day be designers for the Pluto rover, but can practice their abstract thinking skills now by designing transportation to get to school—a context they can relate to.

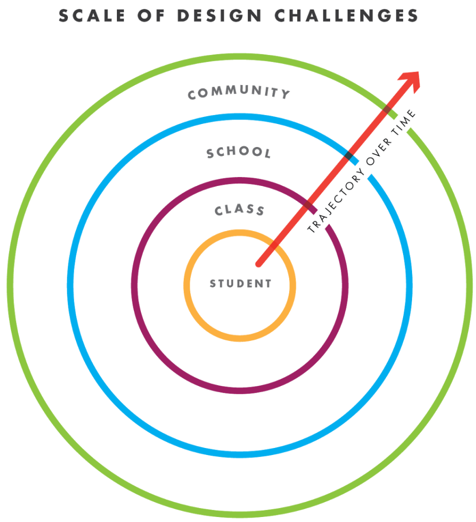

Figure 5. A child in the concrete operational stage mostly comprehends the immediate world around herself, while over time, formal operations are formed, allowing her to think about the greater communities she lives within.

Design process. Vande Zande (2014) lays out an organized design process through stages of planning, execution and exhibition. My proposed curriculum follows this structure and folds in a layer of team process, described in a later section. Vande Zande recommends the following steps of the design process:

1. Identify the problem
2. Investigate and research
3. Generate ideas
4. Prototype
5. Present
6. Evaluate and revise

I chose this model for the design process in the curriculum because it reflects the cycles of the professional design process and common practices in design education. It is recognized that the design process incorporates cycles of revisions, and is not simply a one-way series of steps to a design adaptation (Vande Zande, 2014; Watson, 2015). The design process allows for opportunities of assimilation and accommodation, resulting in adaptation. As students proceed through the curriculum, these steps will become a familiar structure to help build on previous adaptations.

Team Structure

Vygotsky's theories about social construction of knowledge and the ZPD are the foundation for the team-based structure of this curriculum. If knowledge building and cognitive development are influenced by peers, opportunities for learners to work in teams could lead to increased cognitive growth. The age range of ten to twelve is naturally quite a social stage, and we might look to Piaget's theories of egocentrism in younger children to explain this new development. Students are beginning to become a part of the world and social system rather than witnessing it only egocentrically. This design curriculum takes advantage of the natural inclination of this age group for social interaction and focuses their energy on creating adaptations together. These adaptations are mediated through working in a group structure based on Vygotsky's three pillars of his social-constructivist theory: cultural context of knowledge, the individual as part of the social group, and human language (Wertsch, 1988). Students will explore issues of these three pillars as they work through a team design process to create design adaptations.

In this team structure, the size of groups is important. If the team is too large, individuals can't be aware of and react to each individual. Gulley (1968) cites Slater's research on group size that found that:

> "groups larger than four were never felt to be too small, and groups smaller than six were never felt to be too large. The number five emerged clearly, as the size group which, from the subjects' viewpoint, was most effective in dealing with an intellectual task involving the collection and exchange of information about a situation, the coordination, analysis, and evaluation of this information, and a group decision regarding the appropriate administrative action to be takes in the situation." (p. 263)

For this reason, it is recommended that teachers using this curriculum determine groups of five students to set students up for success in working with their teammates.

In this curriculum, the team members will advance through the steps of the design process together. The design process is folded into the team process, with students working together to create design adaptations. The team process differs from the design process in that it mediates interaction among members rather than determining the progression of steps towards creating a design adaptation. Discussion is the foundation of this team process.

Discussion. Vygotsky identifies human language as one of the main channels for social construction of knowledge (Wertsch, 1988). Gulley (1968) also identifies discussion as the delivery system for group process. He says "when the discussion ends, there are particular outputs resulting from the interactions," implying that the discussion among members creates new possibilities that would not arise if individuals were working without the influence of others (p. 249). Since we are concerned with creating fresh and innovative adaptations to design challenges, discussion is key to exploring new ideas.

Through the group process, individuals will have the opportunity to discuss their needs and goals with the team. When the group goals are defined together, members have self-imposed guidelines for participating in the design process. If members establish goals and participate in the design process, the group's agreed-upon goals will be realized. When a group fulfills its goals, the needs of individual members are fulfilled since they have aligned their own needs with the fulfillment of the group goal (Gulley, 1968). This curriculum emphasizes common, shared goals over individual victory or domination. Open and respectful discussion is a vehicle for members to align with group goals, which creates a path for successfully fulfilling group goals, which then fulfills the needs of the individual.

Discussion can be intimidating and uncomfortable for many students. Over time, however, discussion can help individuals become more comfortable expressing thoughts and feelings (Gulley, 1968). This reiterates the importance of discussion as the initial phase of group process.

Goals and consensus. In a productive team, members put the group goals ahead of their individual desires. Members commit to achieving the agreed upon group goals through discussion and consensus and when a group climate is comfortable, members feel empowered. Members must be flexible in roles and tasks, open minded, respectful of other members, comfortable taking risks, and be able to find common ground. In a functional team, conflicts or differences are opportunities to explore new ideas rather than the catalyst for fracture (Gulley, 1968). Throughout the curriculum there are many opportunities for teams to define and revise group goals.

In the early units, it is helpful to allow new teams to establish their own guidelines for harmonious working environments. Creating a list of team member rights and responsibilities can help students navigate the group process and become more autonomous as teams.

Harrington-Mackin (1994) says that teams generally have one thing in common—the need for rules to govern itself. Guidelines are created through class discussion and might include expectations such as being respectful of teammates' ideas, assuming peers are doing their best, disagreeing respectfully, and treating others as equals. Guiding discussion questions are provided in the units to help students adapt to this new system of working. Gulley (1968) identifies three common group goals:

- Striving towards a high quality group product, arrived at efficiently
- Winning individual commitment to the group product where each member is satisfied with the outcome
- Maintaining the group structure by promoting a long-lasting interrelationship to prevent dissolution

It is recommended that group goals, procedures and expectations are evaluated regularly to encourage healthy team functioning (Harrington-Mackin, 1994).

Teachers can help students navigate their group dynamics as adviser and facilitator of group consensus (Gulley, 1968). As teams mature, they might require less facilitator intervention and can learn to manage their own processes. It is important for facilitators to evaluate and reward team performance with a system that encourages healthy group dynamics. The teacher's role as facilitator is further explored in the section below, The individual in the team. Harrington-Mackin (1994) says that team functioning is based on both task completion, or results, and the building of relationships, or the process. Teams can participate in peer performance reviews as teams mature. This can be intimidating for new teams but the benefits are numerous. It is best to assess team performance first before having members conduct individual peer reviews (Harrington-Mackin, 1994).

By creating the opportunity for discussion, groups can establish their own guidelines for working through design challenges. This autonomy gives the team more agency and further develops individual members through the social construction of knowledge. Gulley's (1968) research shows individuals tend to conform to standards determined by the group. He also warns against group rigidity in upholding agreed upon standards, which can lead to discussion becoming sterile and cold. Groups must be flexible in their growth over time.

The individual in the team. As a member of the group, individuals must develop sensitivity to others. "The difference between a group and the same persons as separate, isolated individuals is that individuals, when they become a group, [they] interact and become interdependent" (Gulley, 1968, p. 254). This can be facilitated by establishing group guidelines as mentioned in the previous section, and also by delegating roles and responsibilities. "To understand himself in relation to others he must be perceptive about their ways of viewing. Thus he must understand the operation of the group process, procedures, and functions" writes Gulley (1968, p. 18). Individuals fill roles, and the group dynamics change as roles change. Positions of leadership are expected to behave in a particular way, and these expectations can be determined together by the group members. Gulley (1968) notes that groups tend to be more successful when the role differentiation is clear and well defined.

Students vary in their preferences and strengths in group work, so offering many variations on the group structure accommodates students' individuality (Gulley, 1968). Gulley (1968) says "individuals bring unique talents, abilities and interests; various combinations lead to varied group functioning" (p. 250). While the individual student will always work as a member of the team, this curriculum includes cycles of individual, pair, team and whole class activities that provide opportunities for students with varying comfort levels while working as a group. Some individuals are more willing to participate in a group culture, while some are less willing. It is important to provide options so that all students can find their strengths. People can also change—over time relationships and dynamics within the group will change (Gulley, 1968). This curriculum establishes member roles and responsibilities that respond to the needs of the individuals and the team. While the teams will retain the same members throughout the year-long curriculum, Gulley (1968) recommends that roles change over time, with leadership roles rotated. In this curriculum, I propose the use of four team roles in groups: member, facilitator, adviser, and supervisor.

Team member. Every participant in the class, including the teacher, is first and foremost a team member. Gulley (1968) identifies the team member as an individual who is willing to work together with the group, putting aside individuality to achieve group goals. In other situations she might advocate for her own views more strongly, trying to persuade the group. Both approaches are acceptable as long as members commit to upholding goals, guidelines and responsibilities to maintain group harmony. Unique responsibilities for team members include:

- being prepared for meetings
- attending and participating in discussion
- constructively voicing opinions
- completing assignments
- advancing the overall quality of work from the team

- using resources to help solve team questions
- remaining proactive when things aren't going well for the team
- serving in other roles if needed
- accepting and supporting team decisions (Harrington-Mackin, 1994)

Team Members are also responsible for evaluating facilitators, advisers and the supervisor throughout the team & design processes. Each participant in the curriculum is expected to be a Team Member, including when tasked with filling a leadership role such as adviser or facilitator.

Team facilitator. The first leadership role within each team is identified as the Team Facilitator. The facilitator is responsible for :

- managing the schedule
- managing meeting agendas
- taking notes and organizing ideas to share with team members
- assigning tasks to team members
- modeling leadership behavior
- managing timelines and meeting milestones
- keeping discussion on track
- reporting on the team's support of agreed-upon rules

Additional responsibilities and expectations can be determined through group discussion and consensus.

Team adviser. The Team Adviser is the primary student leadership role within each team. The adviser leads the team to create team purpose by being responsible for:

- communicating to all team members

- helping resolve team conflicts by providing intervention before the supervisor is needed
- helping obtain cooperation
- documenting progress of team
- identifying resources needed and obtains them
- modeling leadership behavior

Team members could require more assistance in the beginning, but can pull back as the team matures and becomes more autonomous (Harrington-Mackin, 1994). The primary role of the adviser is to maintain harmony within the group by acting as a diplomatic and benevolent leader.

Team supervisor. I recommend that the teacher's role in the team structure is to serve as Team Supervisor. Supervisor responsibilities include:

- transmitting knowledge in a timely manner
- applying policies
- providing project specifications
- helping teams work through design challenges by asking questions
- building communication among team members
- helping teams identify what can be done differently if roadblocks occur
- modeling team and leadership behavior including active listening, trust building, and encouraging critical thinking by asking questions
- supporting goals of teams to internal and external sources
- rewarding and reinforcing team behavior
- mediating team conflicts (Harrington-Mackin, 1994)

It is encouraged that while creating class guidelines that the Team Supervisor role and responsibilities are also outlined with the student expectations of team members. Teachers can listen for what students need from them, potentially shedding light on concerns of students unfamiliar with working in a team structure.

It has been shown that the effectiveness of teams is greatly influenced by members' attitudes about the organization, and if team members feel support from management, they experience high productivity (Harrington-Mackin, 1994). It is important for Supervisors to encourage members in their team roles and provide support when needed, but also allow teams space to work through design challenges on their own. Loh (2015) writes that sometimes teachers have a difficult time shifting from an information-giving role to that of a facilitator, and can dominate class discussions. While supervisor support is necessary for functional group processes, the supervisor in this curriculum must maintain balance between helpfulness and student independence. While working through the design process, Vande Zande (2007) says the "teacher needs to clearly define the design problem, define objectives, and determine the manner of assessment" (p. 50).

Life of teams. Students will remain in the same team throughout the year-long curriculum, unless the Supervisor determines there is a significant group fracture that requires intervention. Working within these groups for an extended period of time allows students to grow into their roles and navigate the personal within the group dynamic. Roles will rotate periodically among the five group members, where every member of the class is first and foremost a Team Member, layering in additional responsibilities of leadership roles as their turn arises. Additional team parameters will be outlined in the curriculum; similarly to the design challenges, these parameters will become increasingly abstract conceptually as the students move towards the later units. These team parameters will build on each other, and each will be added to the list of team responsibilities through the curriculum.

The team structures proposed here are meant to facilitate a Vygotskian social-constructivist learning method. Students will learn from their peers as they work through Piagetian adaptations, presented as design challenges, together. Although students will be in the same working groups throughout the curriculum, roles and responsibilities will rotate, which promotes healthy group dynamics. The group becomes the dominant force in the curriculum, with students using their agency as teams to determine the trajectory of their design adaptations.

CHAPTER 5

The Curriculum

In this team-based design curriculum, students will use cycles of the design process to create design adaptations that respond to the design challenge questions. The design concepts of the curriculum begin with concrete ideas and build on each other towards more abstract ideas. Teams also face increasingly abstract group challenges. These strands weave together with Piaget's theory of cognitive development to create a curriculum that has the goal of strengthening formal operations. Each of the units below guides students on this trajectory.

Unit 1: Wearable technology

Design challenge. In this unit, students will be introduced to the design process and experience their first design thinking challenge. They will get to know the peers that become their teammates through the later units. As the first challenge, this unit is based on the most concrete concepts of the curriculum to align with Piaget's stage of concrete operations. Within Vande Zande's four categories of design, *objects* is the most concrete concept, and so the first design challenge is based in this category. Throughout the curriculum, the scale of the design challenges grows to parallel the growth from concrete to abstract thought, and here we will start small—something small that a user would have personal interaction with every day. These design challenges are open-ended, and students have great freedom in determining the trajectory of their design adaptation. Since students of this age group and generation tend to be drawn to personal technology, the first unit will indulge this interest to engage students in the design curriculum. The first design challenge question is: *How could personal technology fit us?*

Design reference. The Alternative Limb Project: Sophie De Oliveira Barata is an artist-designer who provides unique prosthetic technology to blend in with the body or stand out as a unique piece of art. She handcrafts pieces that provide their users with altered experiences and capabilities. Through her design adaptations, she helps people overcome their limitations in beautiful, innovative ways.

Team parameter. Similarly to the scaling of design challenges from concrete to abstract, the team parameters will scale from concrete to abstract, becoming more challenging as the units progress. To learn how to be a team, students must first learn how to behave as a team member. Students will work independently on the design challenge in the first unit, but will meet their peers and build the foundation needed for successful group dynamics. Communication is key to this process, and the first unit is an opportunity for the members of the class to establish the environment for healthy communication. As team supervisor, the teacher models practices for constructivist discussion and set the standards for team expectations. Create a large class brainstorm map on the board based on the following questions:

- What does the word *team* mean? Ex. a group of people working together
- When have you previously been part of a team? Ex. soccer team
- What were your goals as a team? Ex. win soccer games
- How did you work towards these goals? Ex. practice together
- What was challenging about working together? Ex. selfish teammates
- What was fun about working together? Ex. celebrating wins
- What were some of the rules or guidelines you had in the team? Ex. respect each other
- How did you communicate with each other? Ex. listened to each other

- What made you feel like a valued team member? Ex. support from teammates

Everyone in the class, the teacher included, is a team member. Agree upon the guidelines that all members will follow to facilitate communication and healthy team relationships. These may include being prepared for meetings, attending and participating in discussion, voicing opinions, completing assignments, advancing the overall quality of work from the team, using resources to help solve team questions, remaining proactive when things aren't going well for the team, serving in other roles if needed, and accepting and supporting team decisions (Harrington-Mackin, 1994). Post these agreed-upon class guidelines in the room.

Design process. Students will define the steps of the design process, then use the steps to create an adaptation that answers the design challenge question. First, create a class definition of *design*. Then, show the class a list of the design process steps, and use discussion to establish an understanding of what each part of the process might include.

- When have you heard the word *design* before? Where do we see *design*? What do we mean by *design*? Who makes *design*? Who uses *design*? Why do we *design*? How do designers create *design*? The process of designing takes many interesting and different paths, and there is no right or wrong answer, but it does commonly share certain steps.
- What kinds of challenges do you face in everyday life? Do you trip on the same step every day? Or does your shoelace never stay tied? Connect their ideas to the way design plays a role in the situation. The first step in the design process is to *identify the problem*.

- When you face challenges in your day, how do you go about solving them? What would be the first thing you would do? How do you learn more about a subject? *Investigate and Research* is the second step in the design process.
- What ways could we develop ideas together? Brainstorming, mindmapping, sketching, and discussion are possible answers. The third step in the design process is to *generate ideas*.
- How could we make or demonstrate our designs? Possible answers include creating drawings, models, or digital presentations. The fourth step in the design process is to *prototype*.
- How could we share our designs with each other? Other audiences? The fifth step in the design process is to *present*.

How could we use the feedback we receive during presentation? The final step in the design process is to *evaluate and revise*. Following the design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   Who has used some kind of personal technology in the last 24 hours? What did you use it for? What function does our personal technology have in our lives? What other functions could it have? How do you carry around personal technology? What are challenges with using personal technology? What are challenges in transporting personal technology?

2. Investigate and research

   Interview five users of personal technology about their uses and challenges with technology. Identify the current context of the user and potential needs.

- Who are the users of your personal technology? Only you or other people also?
- What are the main functions you use personal technology for?
- Where do you use personal technology? Where do you store it?
- When do you use personal technology?
- Why did you select this type of personal technology?
- How do you use personal technology on-the-go?

3. Generate ideas

   a. Brainstorm

      As a class, discuss the findings of the students' research and work together to explore ideas. Ask open-ended questions of who, what, where, when and why to encourage students in 'digging deeper.' Students ask questions of each other and are the driving force behind the trajectory of the challenge. A mindmap documented on a chalkboard or whiteboard can help lead discussion as a visual aid mapping the collective thought processes of team members.

      What ideal functions could personal technology provide? What ways could it interact with our senses? (beauty, touch, etc.) What would your ideal personal technology be capable of? How could personal technology fit us?

   b. Independent sketching

      Team members have independent sketching time to explore their own ideal creations that answer the design challenge question of "how could personal technology fit us?"

c. Idea sharing

Teams meet and members have the opportunity to openly share their ideas. This is the environment in which the team unit builds trust among members through discussion. Questions to guide idea sharing might include: What features does your design have? How does it function? How does it fit in a user's life?

d. Group consensus

Team members help each other identify their top design idea to execute through discussion. In this design challenge, team members will each be executing their own design idea as a way to stretch their design muscles before working as a team in future units. To obtain group consensus, teams must unanimously vote to approve the designs of their fellow group members. Team members work together to revise and refine ideas to obtain group consensus.

4. Prototype

Use available materials to create models or mock-ups. Throughout the prototyping process, ideas are revisited and revised in a flexible, organic design process. For this personal technology design challenge, artmaking and artisanship skills could include sewing, clay handbuilding, drawing, or digital image editing.

5. Present

a. Team members develop brochures describing their design adaptations. Questions that can help aid in developing content for brochures include:

What was your inspiration for designing this object? What functions do your object provide? How do our senses interact with the designed object? How is your object unique? Who influenced your design decisions? What was the most challenging part of designing? How was the process of working alongside your teammates? How would you approach the design process differently next time?

   b. Display the final prototypes and brochures where class members can walk around and take time to view each other's works. To guide discussion, provide each student with one or two small pieces of paper representing an Instagram 'like.' Students give their 'likes' to their favorite design adaptations. In class discussion, ask students to explain why they gave their 'like' to a certain design.

6. Evaluate and revise

   Students receive compiled feedback from group presentations. Students create proposals for '2.0' versions of their objects to incorporate revisions.

Unit 2: Classroom communication

Design challenge. In the second unit, teams will be challenged slightly more in design thinking and collaboration skills. While students will work through another design challenge related to the concrete category of 'objects,' this unit will layer in the somewhat more abstract category of 'communication.' Students will work as teams to design an object that facilitates communication within and outside the classroom, with the goal of transmitting knowledge. This unit is designed to push students to think slightly more formally—thinking not only about themselves but about communication with the people around them and the outside world. The second challenge question is: *How could a designed object help us learn through communication?*

Design reference. Unbelievable Bus Station: The out-of-this-world graphics and experiences that users see in this promotional video from Pepsi were created through augmented reality. To create this augmented reality scene, designers used a camera, a television screen, and some fancy programming to superimpose UFOs, Godzilla, and explosions on an everyday street. Users see the everyday scene they are used to, but experience an exchange of information with the object, known as communication. Designers created an object that communicates by altering reality and bringing the impossible into a possible space.

Team parameter. In this unit, the members will take another step towards becoming functional teams. The teacher will introduce the team roles and responsibilities outlined in the previous chapter. As a class, discuss the expectations and responsibilities that each of these roles play.

- What were some of the steps in creating our last designs?
- Who made the decisions that went into those steps?
- When working with other people, how do you divide up these responsibilities?
- What do these titles mean to you? Review the vocabulary used for team roles: member, adviser, facilitator, and supervisor. Ex. what does the word *adviser* mean?
- Everyone in this class, including the teacher, is first and foremost a team member. We all share the responsibilities and guidelines we created in the first unit. We will rotate the other roles throughout the school year and everyone will experience each position.
- What kinds of responsibilities might be unique to each team role? Adviser, facilitator, supervisor?

- Who might be the supervisor in this class? The teacher! Supervisor responsibilities may include transmitting knowledge in a timely manner, applying policies, providing project specifications, helping teams work through design challenges by asking questions, building communication among team members, helping teams identify what can be done differently if roadblocks occur, modeling team and leadership behavior including active listening, trust building, and encouraging critical thinking by asking questions, supporting goals of teams to internal and external sources, rewarding and reinforcing team behavior, and mediating team conflicts (Harrington-Mackin, 1994).
- How might the adviser and facilitator roles differ? What responsibilities would be the most important for your team?
- Establish consensus for team roles and responsibilities. Decide how to assign roles for the first team challenge; random selection, class nominations, seating assignments, or teacher's choice are all possible methods.

Design process. The following design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   Who are the people that use a classroom environment? Who communicates in this environment? Who else do you learn from in a classroom? Who could you learn from outside the classroom? What resources outside of the school could be helpful in the classroom? What are other methods of communication besides speech? Where in the classroom might you use communication? When do you use communication in the classroom? Why is communication important for a classroom? How do we learn through communication with others? How could a designed object help us learn through communication?

2. Investigate and research

   Examine the classroom environment and document existing methods of communication such as signs, whiteboards, computers, and loudspeakers, through sketching and writing. These are all designed *objects* that facilitate *communication*.

   - Who uses the communication objects in the classroom?
   - What are the different purposes of these objects?
   - Where are these objects placed?
   - When are they used?
   - Why are these objects designed in this way?
   - How does this object contribute to classroom learning?

3. Generate ideas

   a. Brainstorm

      As a class, use a large sheet of paper and markers to draw icons describing the various communication objects found during investigation. Encourage students to expand on these ideas and draw modified designs of existing objects in innovative ways.

      What ideal functions could classroom communication objects provide? How could a designed object help us learn through communication?

   b. Independent sketching

      Team members have independent sketching time to explore their own ideal creations that answer the design challenge question of "How could a designed object help us learn through communication?"

c. Idea sharing

Teams meet and members have the opportunity to openly share their ideas. Questions to guide idea sharing might include: What features does your design have? How does it function? How does it contribute to our classroom learning?

d. Group consensus

To obtain group consensus, team members will anonymously vote for their favorite design idea to execute as a team, not including their own design. Continue runoff voting until group consensus is reached.

4. Prototype

Use available materials to create models or mock-ups. Throughout the prototyping process, ideas are revisited and revised in a flexible, organic design process. For this classroom communication design challenge, artmaking and artisanship skills could include sculptural modeling, painting, or digital image editing.

5. Present

a. Teams work together to develop poster presentations describing their design adaptation. Questions to ask of presenters:

What were your steps towards designing this final object? What function does your object provide? How does the designed object impact communication? What is its benefit to students? To teachers? To the school? How does it help a student learn? How is your design unique? Who on your team made these design decisions? What was the most challenging part of designing? How was the process of working with your teammates? How would you approach the design process differently next time?

Audience provides questions and feedback.

b. Display work through hallway exhibition to share ideas outside the walls of the classroom.

6. Evaluate & revise

Teams receive compiled feedback from presentations. Teams create proposals for '2.0' versions of their communication objects to incorporate revisions.

Unit 3: Media center

Design challenge. In the third unit, students will work on a slightly more abstract challenge that is concerned with Vande Zande's category of *communication*. We will move outside of the classroom walls as students will examine the current state of the school's library, or media center. Teams will also progress in their growth by shifting roles for the first time, experiencing new responsibilities. The third design challenge question is: *How could users in the media center use design?*

Design reference. NPR Digital School Library: Libraries today are going digital and many are renaming themselves as 'media centers' to broaden the definition of what a user would find there. Media centers are becoming more welcoming, more interactive, and more social in the 21st century. These shifts reflect our changing worlds and the new ways that we communicate and receive information. Librarians and designers are working together to create a new space that facilitates communication—the foundation of how we learn.

Team parameter. Team members experienced the various responsibilities and expectations of team roles in the previous unit, and in this unit will experience the responsibilities of a new role. All members will rotate from the role they filled in the previous challenge. Possible ways to assign new roles are through random selection, seating assignments, or supervisor's choice.

Design process. The following design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   Who are the people that use the media center? What are the purposes of the library? What are the goals of the people that use the media center? What might entice students to come to the library? Where is the most useful information in the media center? When do you use the media center? Why is the media center setup the way it is? How does the media center help us learn?

2. Investigate and research

   Spend a set amount of time in the media center, conducting observational research. Watch the users of the library and document their interactions with the objects and space.

   - Who is using the space?
   - What aspects of the media center is being used? Books? Computers?
   - Where do the users spend most of their time?
   - When do users come to the media center?
   - Why do users come to the media center?
   - How do users interact with the environment in the media center?

3. Generate ideas

    a. Brainstorm

    Ask students to write down three of the media center's areas of need. For each area, students will propose at least one design idea that could help fill this need. Use these ideas as the basis of a class discussion to explore the possibilities of design.

    What ways could our communication be designed? How could users in the media center use design?

    b. Independent sketching

    Team members have independent sketching time to explore their own ideal creations that answer the design challenge question of "How could users in the media center use design?"

    c. Idea sharing

    Teams meet and members have the opportunity to openly share their ideas. Questions to guide idea sharing might include: What features does your design have? How does it function? How does it benefit the users of the media center?

    d. Group consensus

    To obtain group consensus, team members will openly vote for their favorite design idea to execute as a team, not including their own design. Continue runoff voting until group consensus is reached.

4. Prototype

Use available materials to create models or mock-ups. Throughout the prototyping process, ideas are revisited and revised in a flexible, organic design process. For this media center communication design challenge, artmaking and artisanship skills could include architectural modeling, sculptural installation, or free digital 3D modeling like SketchUp.

5. Present

    a. Teams work together to develop a digital slideshow (using free technology such as Prezi, HaikuDeck, or Google Slides) to describe their design adaptation.

       Questions to ask of presenters:

       What were your steps towards designing this media center feature? What function does your design provide? How does the design impact users? What is its benefit to students? To teachers? To the school? How does it help a student learn? How is your design unique? Who on your team made these design decisions? What was the most challenging part of designing? How was the process of working with your teammates? How would you approach the design process differently next time?

       Audience provides questions and feedback.

    b. Display work in the media center, as close to the intended space of the designed object as possible to provide context for students' adaptations.

6. Evaluate & revise

   Teams receive compiled feedback from presentations. Teams create proposals for '2.0' versions of their media center communication designs to incorporate revisions.

Unit 4: Athletic village

Design challenge. In the fourth unit, students will respond to a slightly more abstract design challenge and team-building challenge. While the media center is typically a space that individuals interact with, the athletic space hosts groups of people, from inside and outside the school. Vande Zande's design categories that apply are *communication*, building on the previous unit, and the introduction of *environments*. The athletic environment requires many forms of communication, including event advertising, loudspeaker systems, and graphic systems like school mascots and colors. Students will investigate and research the current athletic environments of the school as the foundation for generating ideas about their own design adaptations. For the team parameter of the unit, students will be responsible for determining the method of assigning roles and responsibilities. By weaving together a design challenge about team-oriented environments with a team challenge of delegation, the unit pushes students to stretch their formal operations. The design challenge question is: *How could design create an athletic village?*

Design reference. Prismen Sports Complex, Copenhagen, Denmark (http://prismen.kk.dk): The traditional ways of using athletic facilities are falling by the wayside. While we still gather to celebrate school spirit and cheer our peers to victory, there are opportunities to modify the typical gymnasium environment to encourage activity, fun, interaction, and community. Danish architect Dorte Mandrup designed the Prismen complex as a hub of activity, sport, and culture that defines a neighborhood community in Copenhagen.

Team parameter. In this unit, members will be challenged slightly more in building a functional design team. In the previous unit, students experienced new roles and unique responsibilities, and in this unit they will determine the method of assigning roles. Team members will nominate and elect roles in a process that they deem fit. Possibilities might include democratic vote, nominations, random selection, or group discussion and consensus. Teams will also be responsible for determining their ideal method of obtaining group consensus, whether through open voting, anonymous voting, democratic discussion, or other methods.

Design process. The following design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   What is your favorite way to exercise? What are your favorite sports? How do you use the school's athletic village? How do you use the athletic village with other students? Who are other people that use the athletic village? What are the purposes of the athletic spaces? What are the goals of the people that use the athletic village? What entices students to come to the athletic village? Where are the most important features of the athletic village located? When do you use the athletic village? Why is the athletic village arranged the way it is? How does the athletic village benefit us? What qualities are important in sportsmanship? How could the athletic village be designed to promote community or sportsmanship?

2. Investigate and research

   Students will examine the existing athletic spaces in the school and sketch floor plans describing the physical spaces. Using tracing paper, students will layer over a sketch describing behavior patterns of the users, such as walking paths or high use areas.

   a. Who uses the environment?

b. What do they use the environment for?

c. Where in the environment are the most important features? Least important?

d. When is the environment used?

e. Why do we have this environment?

f. How could we design an athletic village?

3. Generate ideas

a. Brainstorm

In the athletic space or an open area of the school or school grounds, gather the class for a physical brainstorming activity. Students will throw or kick a ball to each other, and when they catch it, will provide an idea about their ideal athletic space. Document ideas on a large sheet of paper.

What ideal functions could an athletic village environment provide? How could the athletic village be designed to encourage activity? What ways could we build community and teams?

b. Independent sketching

Team members have independent sketching time to explore their own ideal creations that answer the design challenge question of "How could design create an athletic village?"

c. Idea sharing

Teams meet and members have the opportunity to openly share their ideas. Questions to guide idea sharing might include: What features does your design have? How does it function? How does it contribute to our athletic village?

d. Group consensus

   Since teams are now responsible for determining the method for assigning roles, they also must determine their ideal way to obtain group consensus. In previous units, students used discussion and voting to determine design trajectories, and now have freedom to choose a method that suits them.

4. Prototype

   a. Use available materials to create models or mock-ups. Throughout the prototyping process, ideas are revisited and revised in a flexible, organic design process. For this athletic village design challenge, artmaking and artisanship skills could include fabric arts, architectural modeling, or graphic design.

5. Present

   a. Teams work together to develop presentation videos describing their design adaptation. Students can shoot video of the environment and their design adaptation on phones or other available technology and edit using free software like Filmora. Questions to ask of presenters:

      What were your steps towards designing this final environment? What function does your environment provide? How does the designed environment impact our school community? What is its benefit to students? To teachers? To the school? How does it help a student grow? How is your design unique? Who on your team made these design decisions? What was the most challenging part of designing? How was the process of working with your teammates? How would you approach the design process differently next time?

Audience provides questions and feedback.

b. Display work on the school or class website and gather feedback.

6. Evaluate & revise

a. Teams receive compiled feedback from presentations. Teams create proposals for a ‘5-year plan’ for their athletic village environments to incorporate revisions.

Unit 5: Food system

Design challenge. In the fifth unit, students will consider the current food system of the school and propose design adaptations responding to a more abstract challenge question. In this unit, the more abstract team challenge is that teams will add the responsibility of selecting the method of investigation in addition to the previous team parameters. Now, instead of the teacher-supervisor determining all the steps of the design process, the team members begin to take responsibility. By the end of the unit, students will be a step closer on their trajectory to strengthening formal operations, because of the weaving together of the design process and the team process. This unit will build upon the previous units related to *environments*, but will layer in the Vande Zande category of *experiences*. Eating is a daily experience, shared by people in a particular environment. Designed systems are in place for the delivery, preparation, and serving of food. The design challenge question in: *How could we design a better food experience?*

Design reference. School Cafeteria Food vs. Prison Food (Column Five, 2011): While schools provide students with energy to get them through the day, it has been shown that the food experience in schools has room for improvement. This infographic design communicates information about the state of the food we eat in schools. By communicating information, it educates its audience and prompts designers to question the current state of the food environment and experience.

Team parameter. To continue strengthening the team dynamic, members will take on additional team challenges in this unit. In addition to the previous team parameters, in this unit the teams will be responsible for selecting and initiating investigational methods for the second step of the design process. After defining the problem through class discussion in design process step one, help members develop ideas for step two, Investigate and Research:

- What are the current parts of the food system?
- How do they operate?
- Who operates the food system?
- Where does our food at the school come from?
- What aspect of the current food system do you use?
- What can we observe and document?
- What kind of data will you collect?
- How will you document your data?

Possibilities for student-driven research methods include surveys, interviews, or observation of the environment in use.

Design process. The following design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   Who are the people that use the food system? Who are the people that operate the food system? What are the purposes of the food system? What are the goals of the people that use the food system? What might entice students to come to the food environment? Where is the most useful information in the food system? When do you use the food system? Why is the food system setup the way it is? How does the food system help us grow?

2. Investigate and research

   Use the discussion questions from the team parameter to help students identify their research focus and method of inquiry. Students will create their own questions of who, what, where, when, why, and how. Teams will determine their own method for gathering data related to the design challenge. Possibilities could include interviewing cafeteria workers, surveying students or teachers who purchase food at school, or observing the food environment in use.

3. Generate ideas

   a. Brainstorm

      Provide students with paper plates and markers, and have them write their name on the front. Students should write or draw an idea on their plate and pass it to their neighbor. Continue adding ideas and passing plates until everyone has added an idea to everyone else's plate. Teams will use these plates as basis for discussion in the idea sharing step.

      Where does the food come from and where could it come from? What is an opportunity in our school to make it healthier/fresher/less expensive/more local? How can we work together to provide the best food for each other? How could we design a better food experience?

b. Independent sketching

   Team members have independent sketching time to explore their own ideal creations that answer the design challenge question of "how could we design a better food experience?"

c. Idea sharing

   Teams meet and members have the opportunity to openly share their ideas, using the paper plate brainstorms as a guide. Questions to guide idea sharing might include: What features does your design have? How does it function? How does it contribute to our food system?

d. Group consensus

   Teams should now be responsible for determining their ideal method of obtaining group consensus.

4. Prototype

   a. Use available materials to create models or mock-ups. Throughout the prototyping process, ideas are revisited and revised in a flexible, organic design process. For this food system design challenge, artmaking and artisanship skills could include infographic design, sculptural models, or landscape design in the form of edible gardens for the school.

5. Present

   a. Teams work together to develop a website homepage describing their design adaptation. This could be done in many ways, not limited to technology or knowledge of HTML. Analog possibilities include artmaking skills like drawing, painting, or hand-made graphic design. Free and easy real-life website builders include Edublogs, Weebly, or Wix. Questions to ask of presenters:

What were your steps towards designing this final design adaptation? What function does your design provide? How does the designed environment change a user's experience? What is its benefit to students? To teachers? To the school? How does it help a student's life? How is your design unique? Who on your team made these design decisions? What was the most challenging part of designing? How was the process of working with your teammates? How would you approach the design process differently next time?

Audience provides questions and feedback.

   b. Promote the websites for feedback and viewing through take home flyers, a class social media account, or the school website. A link to a free survey can be added to most websites, which can be used to collect feedback from an audience.

6. Evaluate & revise
   a. Teams receive feedback from presentations. Teams create proposals for a 'senior class gift' that represents revisions to their food system design for the future year of their high school graduation.

Unit 6: Transportation

Design challenge. In the sixth unit, students will continue to strengthen their formal operations by combining a design challenge related to transportation with a more abstract team challenge of taking on more autonomy in the decision making process. The design challenge is to examine the current system of transportation that leads to the school, and imagine possibilities for it. Transportation is both an *environment* and an *experience*. Transportation environments includes aspects like signage and maps, shelters for waiting passengers, or the design of the routes and paths that we take. Transportation experiences include passenger wait times, loading and unloading systems, and the ride itself. The design challenge question is: *How could we design a better transportation environment and experience?*

Design reference. Copenhagen's Bike Skyway (George, 2014): The Copenhagen Bike Skyway represents a modern feat of ingenuity and engineering that puts its users first. What is more fun than riding your bike along swooping paths while you're suspended over water? This example of combining environment with experience demonstrates how designers think ahead to the future people that will use their work—designers call this 'empathy.' People like to enjoy their surroundings in daily life, and it is designers who create these experiences.

Team parameter. Building on the team parameters of the previous units, the teams will add a new responsibility in this unit. In addition to determining the method of investigating and researching, teams will determine the trajectory of an additional design process step: generating ideas. Ask team members questions to help make these decisions:

- What methods have we previously used for generating ideas? What are your favorites? Least favorite?
- What were the most successful methods of generating ideas? Least successful? Why?
- How else might we generate ideas?
- How will your team generate ideas for designing?

Draw on the experiences from the previous units to help teams identify the trajectory for their own design process.

Design process. The following design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   Who uses transportation to get to school? What kinds of transportation are used? What kinds of environments do you encounter on the way to school? What sequence of experiences do you follow? (i.e. walking to the bus stop, waiting at the bus stop, loading onto the bus, riding on the bus, etc.) Where does your transportation take you? When might you use a different form of transportation? Why do you use a certain form of transportation? How far away are you traveling from? How much time does it take to get to school? How enjoyable is the ride? How could exercise be incorporated into our school transportation?

2. Investigate and research

   Use the discussion questions from the Unit 5 team parameter to help students identify their research focus and method of inquiry. Students will create their own questions of who, what, where, when, why, and how. Teams will determine their own method for gathering data related to the design challenge.

3. Generate ideas

   Teams will determine their own methods for brainstorming, sketching, sharing, and obtaining group consensus. Use the guiding questions in the team parameter to assist teams in developing their ideas. How could we design a better transportation environment and experience?

4. Prototype

Use available materials to create models or mock-ups. Throughout the prototyping process, ideas are revisited and revised in a flexible, organic design process. For this transportation design challenge, artmaking and artisanship skills could include perspective drawing, map design, or digital vector drawing.

5. Present
    a. Teams work together to develop an app interface that describes their design adaptation. This could be done in many ways, not limited to the use of expensive technology. Possibilities include creating paper mock-ups, slideshows, or a social media campaign.
    b. Promote the app interfaces for feedback and viewing through take home flyers, a class social media account, or the school website. A link to a free survey can be added to most websites, which can be used to collect feedback from an audience.
6. Evaluate & revise
    a. Teams receive compiled feedback from presentations. Teams create proposals for a futuristic plan of their transportation systems to incorporate revisions.

Unit 7: Emergency!!!

Design challenge. In this unit, students will work together to design possibilities for the prevention, relief or recovery of disasters & emergencies. As the seventh unit, students would be farther down the path of transitioning from concrete to formal operations. This unit layers in more abstract design thinking principles such as envisioning a hypothetical event and empathy for others. This design challenge is related to Vande Zande's category of *experiences*. Part of being human is experiencing the unexpected; unfortunately, emergencies and disasters are an unavoidable aspect of life. Designed objects, communication, and environments can help in times of need, easing the experiences of those affected. The seventh design challenge question is: *How could design help in case of emergency?*

Design reference. Design 4 Disaster: This online resource provides many existing innovative ideas about how design can help in case of emergency. Disasters and emergencies are an unavoidable part of life, and the way that humans overcome challenges is called 'design.'

Team parameter. The team dynamics will be challenged slightly more in the seventh unit, pushing towards strengthening formal operations. In this unit, the team will create their own schedules for completing the steps of the design process. Together, they must be flexible and overcome unexpected challenges like snow days or fire drills. Provide a final deadline and allow the teams or class to schedule the steps of the design process.

- How much time will you need for each step?
- What steps might take longer than others?
- What is the most challenging step?
- What are some challenges to creating a schedule?
- How will you hold your team accountable to your agreed-upon deadlines?

Design process. The following design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   Who has experienced an emergency? What kinds of experiences might be emergencies? Disasters? What kinds of emergencies or disasters happen in this area? What might happen if these occurred during school? What systems are in place for emergencies or disasters at school? Where do we go? When might an emergency occur at school? Why do we follow certain guidelines? How do we learn from our experiences? How do we create these systems?

2. Investigate and research

   Use the discussion questions from the Unit 5 team parameter to help students identify their research focus and method of inquiry. Students will create their own questions of who, what, where, when, why, and how. Teams will determine their own method for gathering data related to the design challenge.

3. Generate ideas

   Teams will determine their own methods for brainstorming, sketching, sharing, and creating group consensus. Use the guiding questions in the Unit 6 team parameter to assist teams in developing their ideas.

4. Prototype

   Use available materials to create models or mock-ups. Throughout the prototyping process, ideas are revisited and revised in a flexible, organic design process. For this emergency design challenge, artmaking and artisanship skills could include sculptural modeling, performance art, or video editing.

5. Present

   a. Teams work together to develop an emergency preparedness presentation that describes their design adaptation. Possibilities include creating paper mock-ups, social media campaigns, graphic design posters.

b. Display work through hallway exhibitions, district art exhibits, or online and gather feedback for revisions.

6. Evaluate & revise

   a. Teams receive compiled feedback from presentations. Teams create proposals for next generation designs of their emergency adaptations to incorporate revisions.

Unit 8: Community event

Design challenge. As the final unit in the curriculum, this is the most abstract concept, which reaches beyond the concrete thinking students began the school year with. The design challenges have grown in scale, from an object that a student could wear to thinking about the school as a whole in Unit 7. Here, we will reach outside the school walls to the larger community. Every community has challenges and needs, and teams will be challenged to think of ways to benefit the community through designed experiences—possibly a gallery show, fundraising effort, or community cleanup event. The design challenge question is: *How could we benefit our community with a designed experience?*

Team parameter. In this final unit, the design teams will be challenged to determine their own path through the design process. They will determine their own method for every step of the team-based design process, including assigning roles, defining the problem initiating investigation, generating ideas, scheduling, and presenting.

Design process. The following design process steps lead the class to creating design adaptations that respond to the challenge question.

1. Identify the problem

   Teams ask their own questions of who, what, where, when, and why to identify the current challenges and needs in the community.

2. Investigate and research

   Use the discussion questions from the Unit 5 team parameter to help students identify their research focus and method of inquiry. Students will create their own questions of who, what, where, when, why, and how. Teams will determine their own method for gathering data related to the design challenge.

3. Generate ideas

   Teams will determine their own methods for brainstorming, sketching, sharing, and creating group consensus. Use the guiding questions in the Unit 6 team parameter to assist teams in developing their ideas.

4. Prototype

   Teams will determine their own methods for prototyping their design ideas. How will you create your design idea? What materials will you use? What format will your prototype take?

5. Present

   Teams will determine their own method for presenting. How will you share your design idea? Audience provides questions and feedback.

6. Evaluate & revise

   Teams receive compiled feedback from presentations. Teams will determine the method of revision.

CHAPTER 6

Conclusions

Implementing a team-based design thinking curriculum in middle school complements the natural transition from concrete to formal operations. Formal operations can be strengthened through experiences of challenges and adaptations to challenges. The stage of formal operations describes what makes us uniquely human—the ability to think creatively and create designs that allow us to adapt to the world around us. The transition to the stage of formal operations occurs at a very particular time in our biological development, around the age of middle school. This stage is flexible, and can be strengthened or remain undernourished.

Design education in the 21st century strives to strengthen students' skills of creative thinking. The process of using design thinking to create adaptations mirrors the process Piaget describes in creating adaptations for cognitive development. Implementing the tools of the design process and design thinking in a middle school classroom could strengthen the skills of formal operations.

One of Piaget's four factors leading to the transition from each stage of cognitive development to the next is social transmission. Piaget believes that children become more social during the transition from concrete to formal operations. Vygotsky's theories of cognitive development echo the importance of social interaction in the learning process. We learn through the exchange of information with those around us. The design process, both in professional and educational settings, is often a team process. The team process benefits the design process through shared knowledge, resulting in higher level formal thinking.

These three threads—Piaget's theory of cognitive development, Vygotsky's theory of social constructivism, and design education—have many interesting connections and opportunities for interaction. This proposed team-based design curriculum, targeted for middle school students, aims to strengthen the skills of formal operations. A series of increasingly abstract design challenges pushes the cognitive development of students as they work in teams that support their learning. While future research could identify other aspects of art and design that uniquely align with Piaget's stages of cognitive development, this curriculum outlines a clear correlation among the design process, team process and cognitive development. In this curriculum, students are not memorizing knowledge but they are learning through constructing knowledge together—knowledge of how to face challenges, how to think creatively, how to ask questions, and how to work together towards a goal. These are the aims of 21st century education.

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